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DEPARTMENT OF THE NAVY
DAVID TAYLOR MODEL BASIN

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HYDROMECHANICS

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AERODYNAMICS

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APPLIED MATHEMATICS

SMOOTH-WATER TESTS OF MODEL 4943 REPRESENTING A 41-FOOT PERSONNEL BOAT

by

Kenneth H. Harbaugh

HYDROMECHANICS LABORATORY
RESEARCH AND DEVELOPMENT REPORT

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NOTATION

A_P	Projected planing bottom area, excluding area of external spray strips
A_W	Area of waterplane at the load waterline
A_X	Area of maximum vertical transverse underwater section
$\mathbb{B}$	Baseline
B_P	Beam or breadth over chines, excluding external spray strips
B_{PA}	Mean breadth over chines, A_P/L_P
B_{PX}	Maximum breadth over chines, excluding external spray strips
B_X	Breadth at the maximum area-section, measured at the LWL
C_B	Block coefficient (volume of the underwater body, ∇, divided by the volume of a rectangular parallelepiped, LWL · B_X · H_X)
CG	Center of gravity
$\mathbb{C}$	Centerline
C_P	Prismatic coefficient (volume of the underwater body, ∇, divided by the volume of the prism, LWL · A_X)
C_W	Waterplane coefficient (ratio of area, A_W, to area of rectangle, LWL · B_X)
C_X	Maximum section coefficient (area, A_X, divided by the area of rectangle, B_X · H_X)
ehp	Effective horsepower
F_∇	Froude number based on volume in any consistent units, $v/\sqrt{g\nabla^{1/3}}$
g	Acceleration due to gravity
H	Draft of underwater hull, measured from B_L to LWL
H_X	Draft at the section of maximum area
LCG	Longitudinal center of gravity location
LOA	Length overall
L_P	Projected chine length

LWL	Load waterline or length on load waterline
R	Total resistance; lb
S	Area of wetted surface (This is the actual wetted surface underway including the area of the sides which is wetted at low speeds and the wetted bottom area of external spray strips; however, the area wetted by spray is excluded.)
V	Speed; knots
v	Speed
w	Density of water, weight per unit volume
Δ	Displacement at rest, weight of
∇	Displacement at rest, volume of
τ	Trim angle of hull with respect to attitude as drawn; deg

ABSTRACT

Tests, using TMB Model 4943, were conducted in Langley Tank No. 1 to determine the performance characteristics of a round bilge 41-foot Personnel Boat. Model resistance, trim, wetted length, and CG rise were measured throughout the speed range for a number of hull loadings, initial trim conditions, and appendage configurations. Comparisons are made with the design condition. Results are presented in dimensionless form.

INTRODUCTION

The Bureau of Ships,[1] requested that the David Taylor Model Basin conduct model tests of a 41-foot personnel boat, and the project was undertaken by the High-Speed Phenomena Division under Task No. 2062.

The work assignment as outlined in Reference 1 consisted of two parts:

1. Determination of the resistance and running trim in smooth water.
2. Determination of the resistance, running trim, and motions in irregular waves for conditions of ahead and following seas.

The model tests have been completed for Part 1 in accordance with the conditions as outlined in Reference 1.

The model tests for Part 2 will be completed at a later date and the results will be presented separately.

DESCRIPTION OF MODEL

A 1/6-scale model, designated as DTMB Model 4943, was constructed in accordance with the lines and offsets of Reference 2. Three views of Model 4943 with its appendages are shown in Figure 1. Lines and form characteristics are presented in Figure 2.

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[1] References are listed on page 3.

TEST PROGRAM

Tests of Model 4943 were run in the towing tank of the High-Speed Phenomena Division at Langley Field, Virginia. The test was set up for thrust-line towing and for running in the free to trim condition. A schedule of the model tests is presented in Table 1. Tests 1 through 7 of the schedule were conducted at full-scale speeds ranging from 0 to 31 knots. Test 8, DTMB standard condition, was conducted at full-scale speeds ranging from 0 to 60 knots. Resistance, trim, CG rise, and wetted lengths were measured throughout the speed range and photographs were taken at 5-knot intervals.

TEST RESULTS

Results of the model tests are presented in Figures 2 through 5. The air drag of the towing gear has been subtracted from all resistance data. The full-scale resistance and ehp were calculated by the method described in Reference 3, using the 1947 ATTC friction coefficients with zero roughness allowance. Test data and results for Test 8 are given in Figure 2 for the DTMB standard condition for planing boats.

Figure 3 presents the full-scale resistance ($\frac{R}{\Delta}$) and change in trim for various test conditions. Change in the initial trim at the design load had no appreciable effect on either the resistance or trim (Figure 3a). Change in the configuration caused no appreciable effect on the trim but did reduce the resistance (Figure 3b). At a Froude number of 3.5, removal of the shafts, struts, and rudders reduced the resistance 15 percent; removal of all appendages reduced the resistance 30 percent. The increase in load increased the trim, increased $\frac{R}{\Delta}$ at Froude numbers below 2.8, and decreased $\frac{R}{\Delta}$ at high Froude numbers (Figure 3c).

The nondimensional wetted surface ($\frac{S}{\nabla^{2/3}}$) and rise of the center of gravity ($\frac{\text{CG rise}}{\nabla^{1/3}}$) are presented in Figure 4. Change in initial trim had no appreciable effect on CG rise and only a small effect on wetted area (Figure 4a). Change in configuration caused no significant variation in

CG rise but did change the wetted area by about 10 percent when the keel was removed (Figure 4b). A 5000-lb increase in gross load caused about 10-percent decrease in $\frac{S}{\nabla^{2/3}}$ (Figure 4c).

The total ehp is presented in Figure 5. Initial trim had only a small effect on ehp (Figure 5a). Figure 5b shows that at a speed of 30 knots, removal of the shafts, struts, and rudders reduced the ehp by 70 hp (15 percent), and removal of all appendages reduced the ehp by 123 hp (26 percent). Increase in gross load caused an approximately constant increase in ehp at speeds above 12 knots (Figure 5c). This increase was about 50 hp for a 5000-lb increase in load.

Spray characteristics under various test conditions and at several Froude numbers are presented in Figures 6 through 11. At the design condition of 25,000 lb and even keel, the spray characteristics were the same regardless of configuration; therefore, the photographs (Figure 8) at 25,000-lb displacement and even keel, with no appendages, are considered representative.

REFERENCES

1. Bureau of Ships letter S-F014-02 02, Serial 449-84 of 21 August 1962 to the David Taylor Model Basin.

2. Bureau of Ships Drawing No. 2089577, 41-Foot Personnel Boat, Lines and Offsets.

3. Gertler, M., "The Prediction of the Effective Horsepower of Ships by Methods in Use at the David Taylor Model Basin," David Taylor Model Basin Report 576 (Dec 1947).

TABLE 1

Test Schedule

Test No.	Model Displacement lb	Ship Displacement lb	$\frac{A_P}{\nabla^{2/3}}$	Initial Trim deg	LCG % L_P aft of Centroid of A_P	Configuration
1	114.2	25,000	6.03	EK	2.8	All appendages (design condition)
2	114.2	25,000	6.03	0.5° by bow	1.9	All appendages
3	114.2	25,000	6.03	0.5° by stern	4.5	All appendages
4	114.2	25,000	6.03	EK	2.8	Keel only
5	114.2	25,000	6.03	EK	2.8	No appendages
6	91.3	20,000	7.0	EK	3.9	All appendages
7	137.0	30,000	5.34	EK	3.7	All appendages
8*	91.4	100,000	7.0	0.67° by stern	6.0	No appendages (DTMB standard condition)

* The total resistance has been corrected to a 100,000-lb displacement (DTMB standard condition), which corresponds to a linear ratio of 10.26.

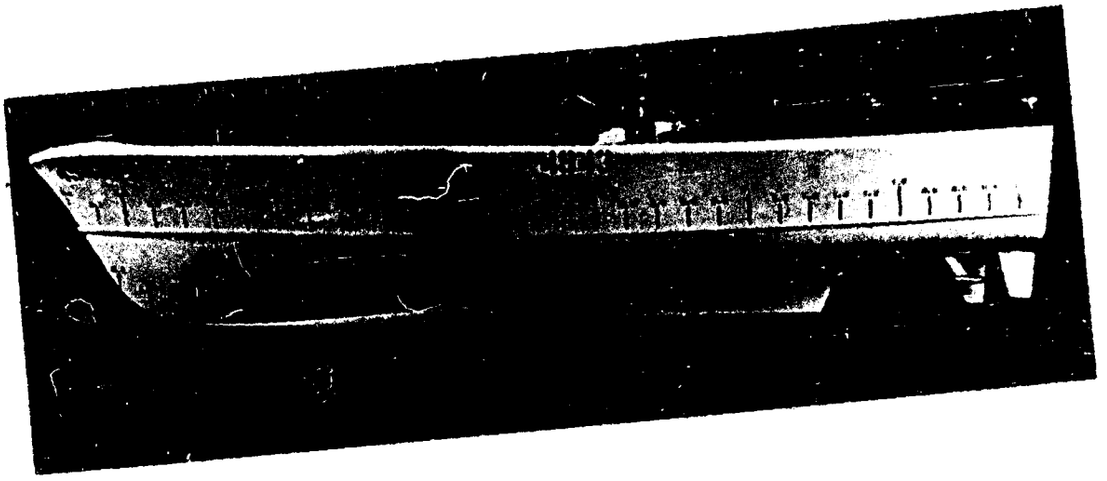


Figure 1a - Side View

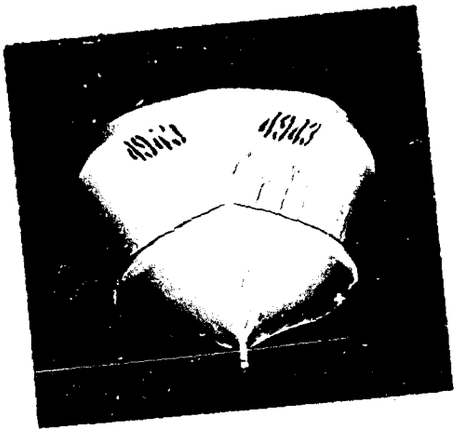


Figure 1b - Bow View

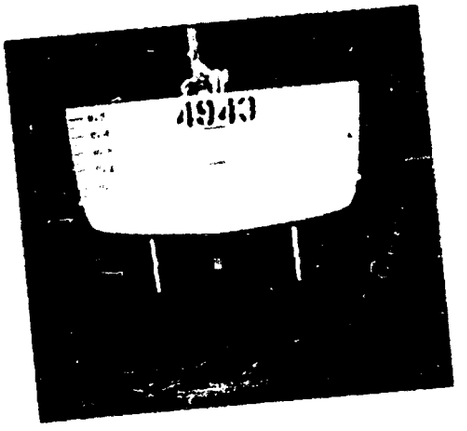


Figure 1c - Stern View

Figure 1 - Photographs of Model 4943

DAVID TAYLOR MODEL BASIN
SMALL CRAFT DATA SHEET
ROUND-BOTTOM BOAT, $L/B_X = 4.01$
TMB MODEL NO. 4943

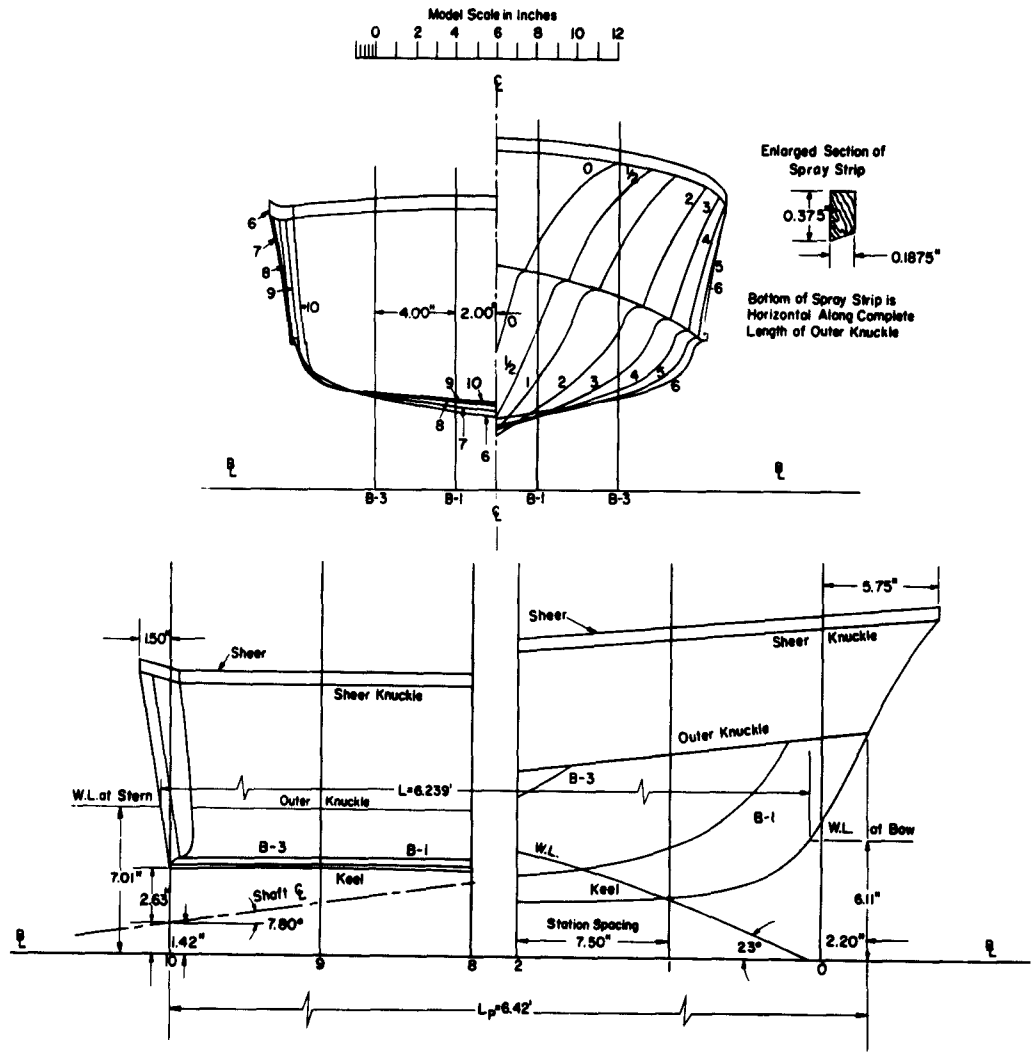


Figure 2A

MODEL PARTICULARS, TEST CONDITIONS, AND RESULTS

Boat 41 ft Personnel Boat
Model Number 4943
Appendages Spray Strip

Laboratory DTMB(Langley Field,Va.)
Basin High-Speed
Basin Size 2880X24X12 ft.
Model Length 6.42 ft
Test 8 Date 10 Dec 62

Water Temperature 49°
Specific Weight 63.2 lb/ft^3
Model Material Wood
Model Finish Paint
Turbulence Stimul. none

Remarks: Model was towed in the shaft line shown in the profile drawing.

Planing Bottom Dimensions and Coefficients

L_P	6.417 ft
B_{PX}	1.704 ft
B_{PA}	1.393 ft
A_P	8.945 ft
$A_P/\nabla^{2/3}$	7.000
$L_P/\nabla^{1/3}$	5.677
L_P/B_{PA}	4.607

LWL Dimensions and Coefficients

L	6.239 ft
B_X	1.557 ft
H_X	0.241 ft
L/B_X	4.006
$L/\nabla^{1/3}$	5.517
C_B	0.618
C_P	0.748
C_W	0.812

Model Test Condition

Δ, lb 91.4 τ_0 0.67 deg bystern α_0 —

LCG location 2.42ft forward of Station 10
(LCG location 6 percent L_P aft of centroid of A_P)

Model Test Results

V, knots	R_T, lb	Wetted length of keel, ft	Wetted length of chine, ft	$Re \times 10^{-6}$	S, ft^2	$10^3\ C_T$	Change of trim, deg	CG rise, in.	F_∇
3.55	5.4	6.2	1.5	1.594	7.20	21.203	1.19	−0.42	0.99
4.15	7.5	6.13	1.6	1.864	7.22	21.576	2.21	−0.54	1.16
4.68	8.7	6.04	1.8	2.137	8.42	16.849	2.61	−0.29	1.31
5.27	9.8	6.0	2.3	2.548	7.72	16.310	2.84	−0.17	1.47
6.10	10.3	6.0	3.8	3.482	9.05	10.918	2.82	−0.01	1.71
7.02	11.7	5.95	3.7	3.941	8.91	9.518	2.70	0.41	1.96
8.03	13.1	5.8	3.5	4.347	8.61	8.434	2.92	0.68	2.24
8.65	13.9	5.7	3.2	4.483	8.29	8.006	3.08	1.03	2.42
10.07	14.7	5.4	3.1	4.985	7.90	6.553	3.32	1.23	2.82
10.96	15.5	5.32	2.6	5.055	7.40	6.229	3.35	1.32	3.06
11.96	16.4	5.1	2.3	5.157	6.91	5.920	3.13	1.50	3.34
13.27	17.3	5.1	2.2	5.641	6.81	5.153	2.78	1.86	3.71
14.63	19.8	5.15	2.1	6.169	6.78	4.872	2.52	1.97	4.09
16.58	23.4	5.20	1.6	6.569	6.40	4.746	2.19	2.00	4.63
18.72	28.6	5.37	1.3	7.261	6.23	4.679	1.91	2.04	5.23

Figure 2B

PERFORMANCE CHARACTERISTICS

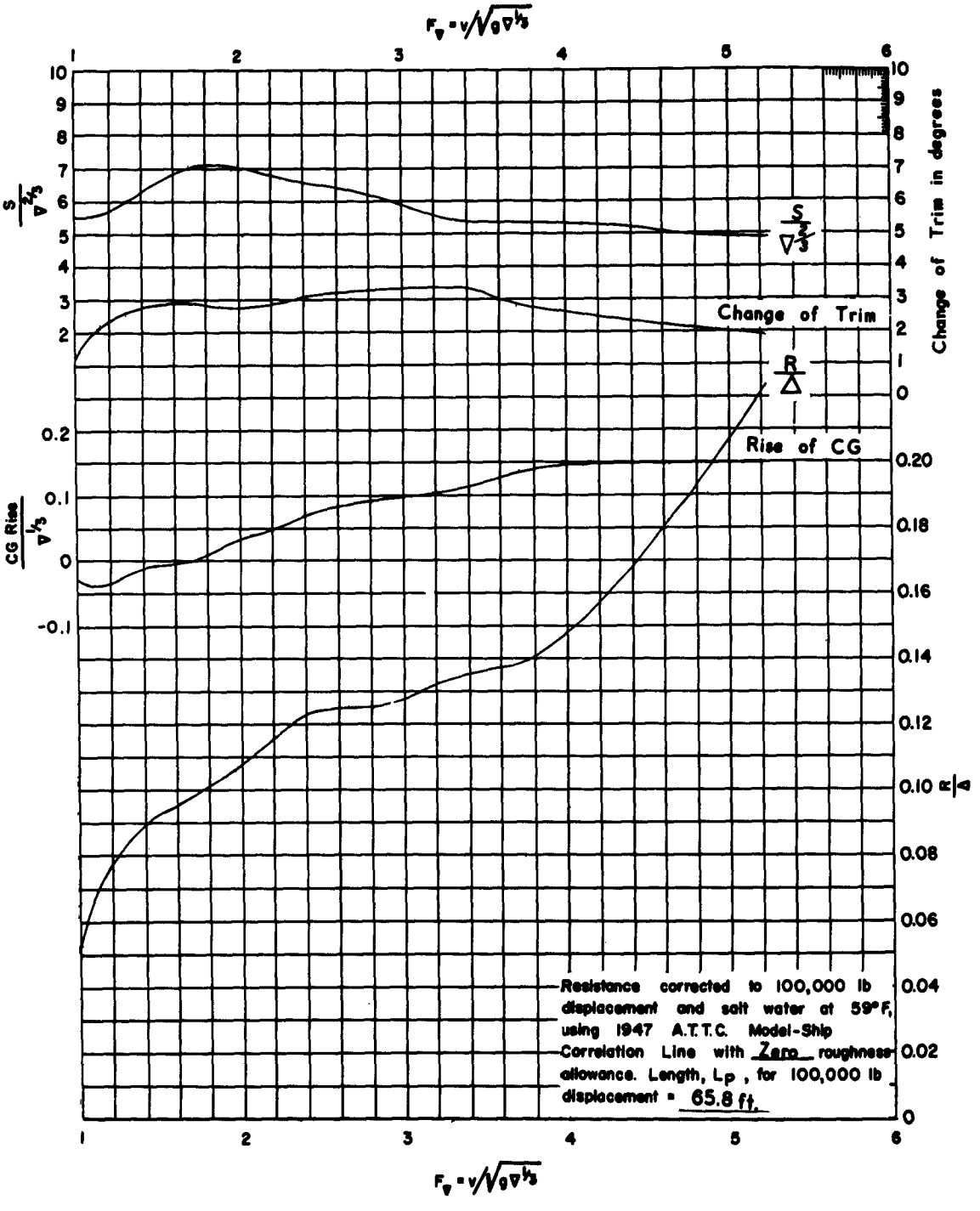
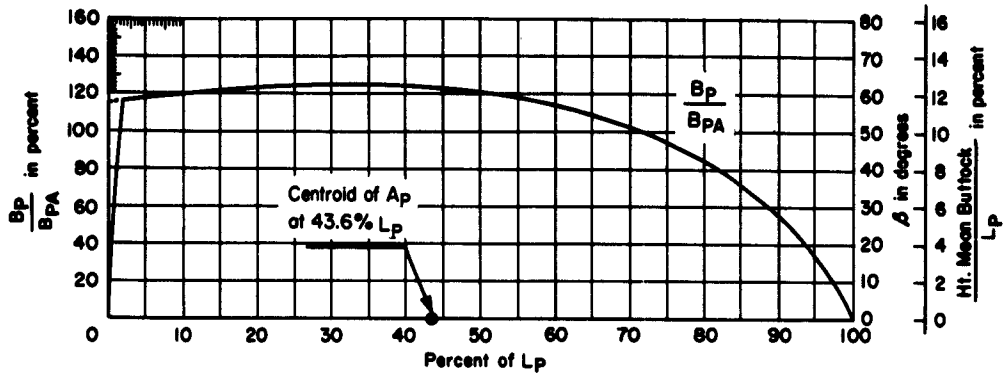
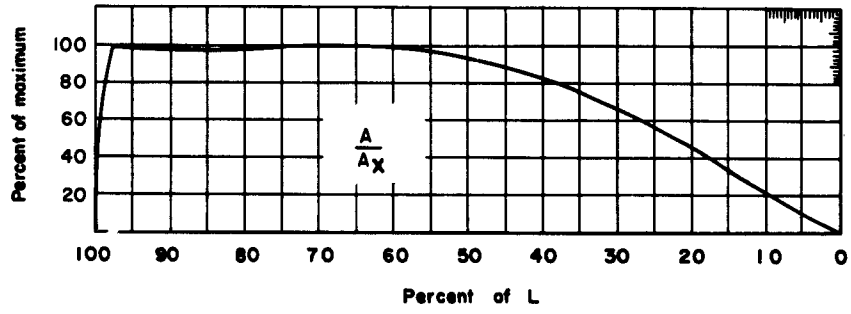


Figure 2C

FORM CHARACTERISTICS





Notation

As far as possible the notation used is consistent with the Society's "Explanatory Notes for Resistance and Propulsion Data Sheets" (Technical and Research Bulletin No. 1-13). Exceptions and additions are listed below. The subscript P designates the planing bottom which is the portion of the bottom bounded by the chines and transom.

A_P	Projected planing bottom area, excluding area of external spray strips
B_P	Beam or breadth over chines, excluding external spray strips
B_{PA}	Mean breadth over chines, A_P/L_P
B_{PX}	Maximum breadth over chines, excluding external spray strips
L_P	Projected chine length
S	Area of wetted surface (This is the actual wetted surface underway including the area of the sides which is wetted at low speeds and the wetted bottom area of external spray strips; however, the area wetted by spray is excluded).
α	Angle of attack of stern portion of planing bottom in degrees
β	Dead rise angle of planing bottom in degrees. This angle is obtained by approximating each body plan section by a straight line.
Δ	Displacement at rest, weight of
τ	Trim angle of hull with respect to attitude as drawn in degrees
∇	Displacement at rest, volume of

Subscript o indicates value when hull is at rest in water.

Figure 20

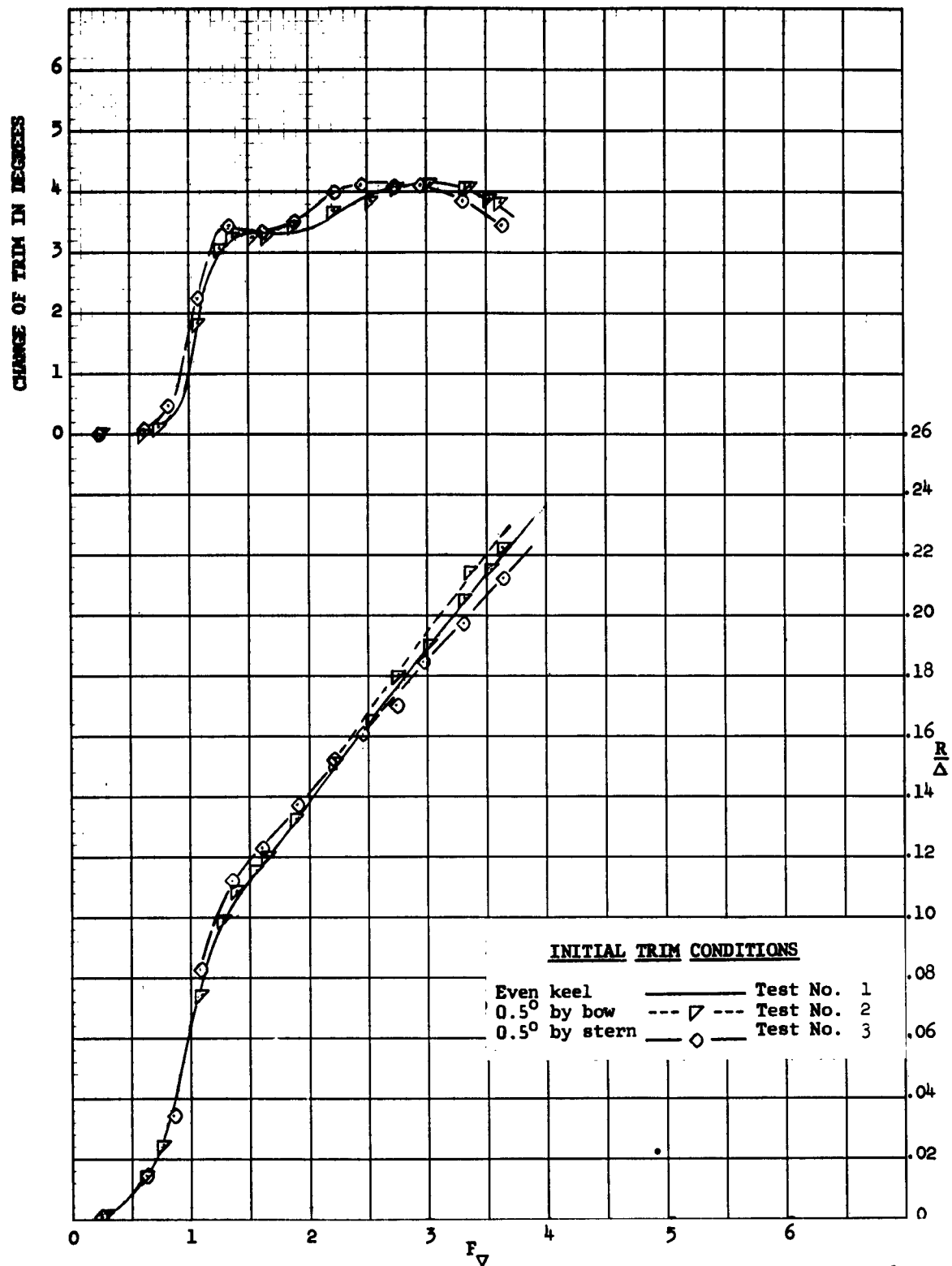


Figure 3a - Variation of Trim and Resistance with Froude Number for Three Initial Trim Conditions at a Displacement of 25,000 Pounds and with all Appendages

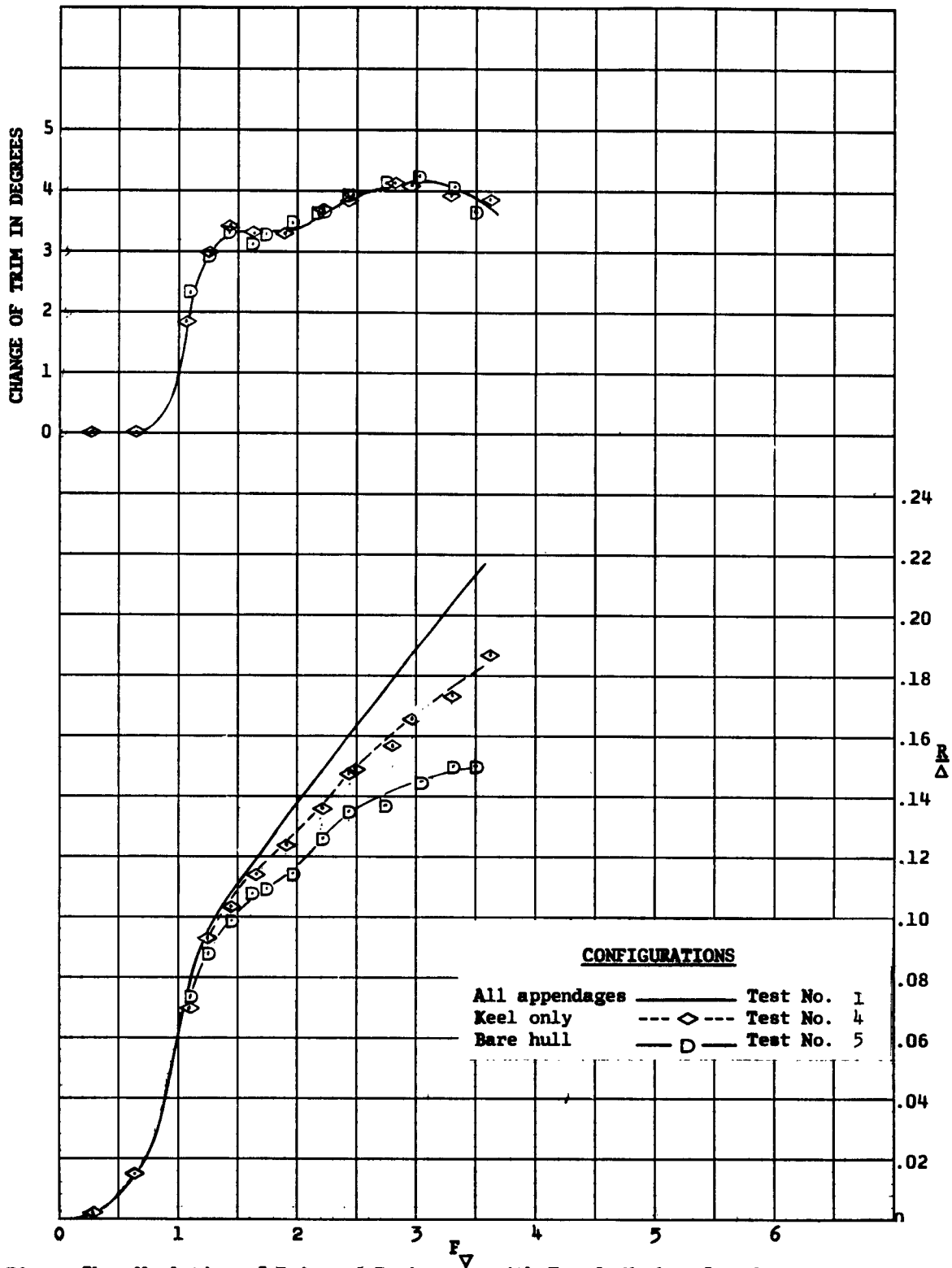


Figure 3b - Variation of Trim and Resistance with Froude Number for Three Configurations at a Displacement of 25,000 Pounds and Even Keel

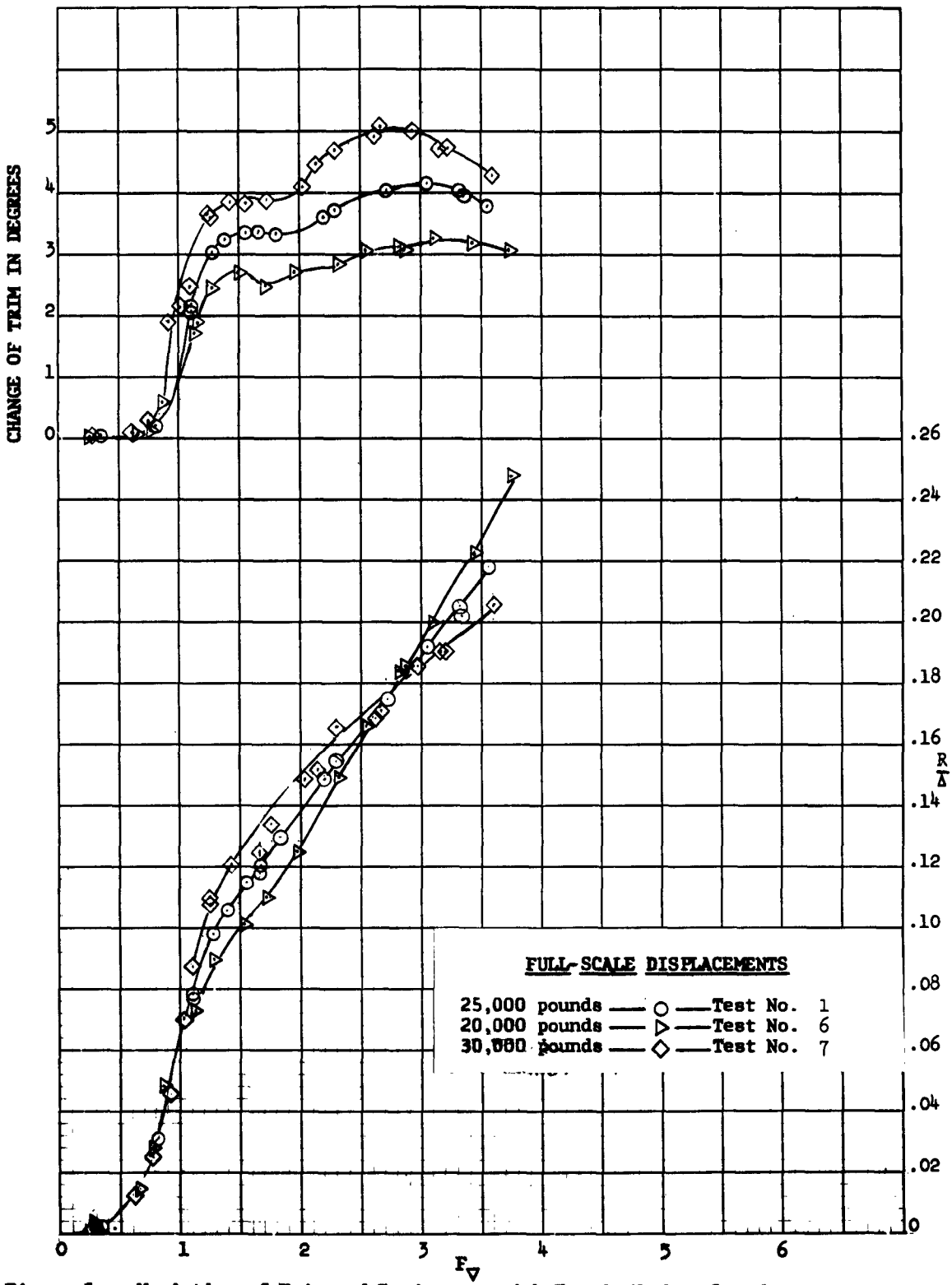


Figure 3c - Variation of Trim and Resistance with Froude Number for Three Displacements at Even Keel and with all Appendages

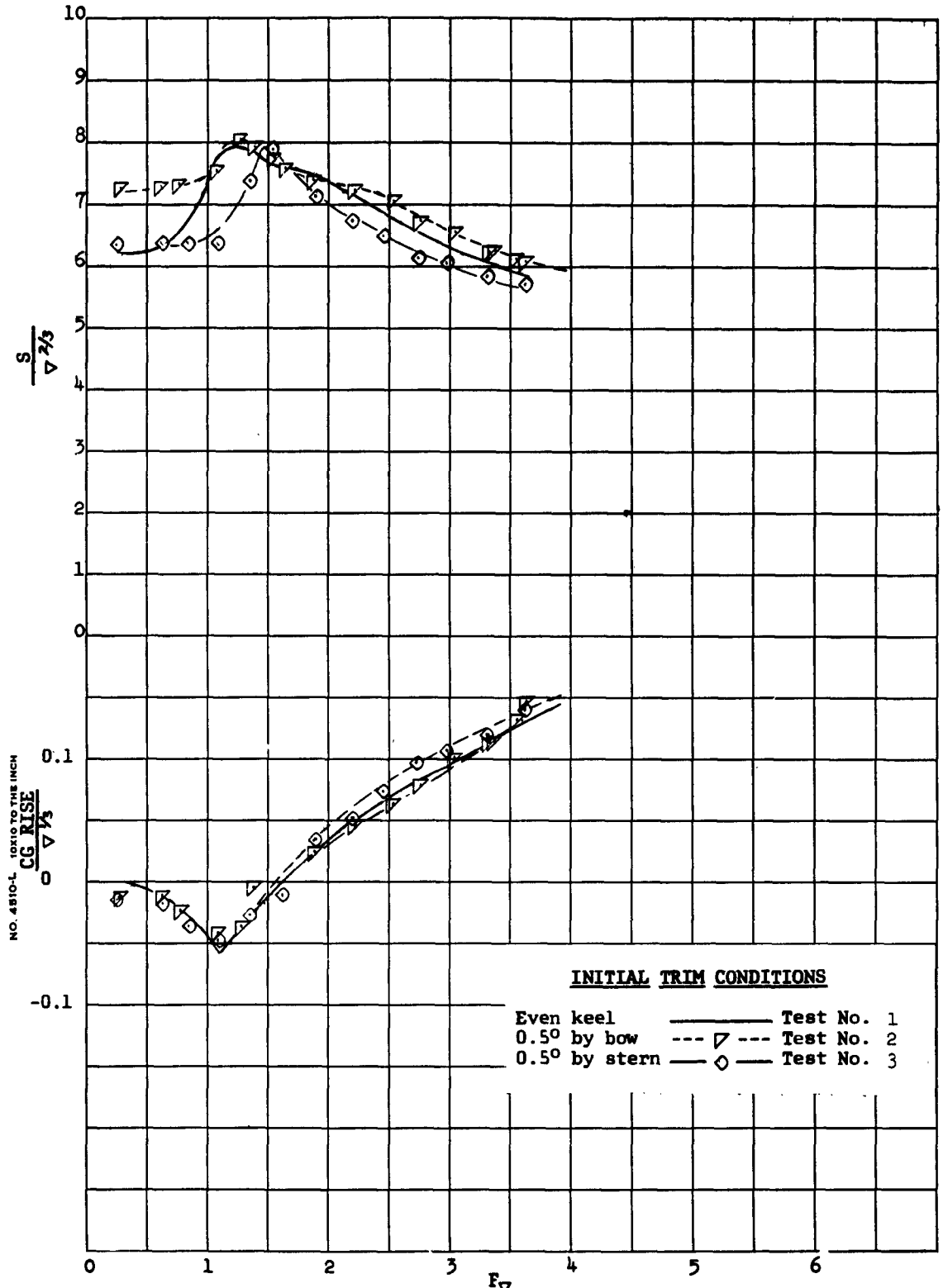


Figure 4a - Variation of Wetted Surface and CG Rise with Froude Number for Three Initial Trim Conditions at a Displacement of 25,000 Pounds and with all Appendages

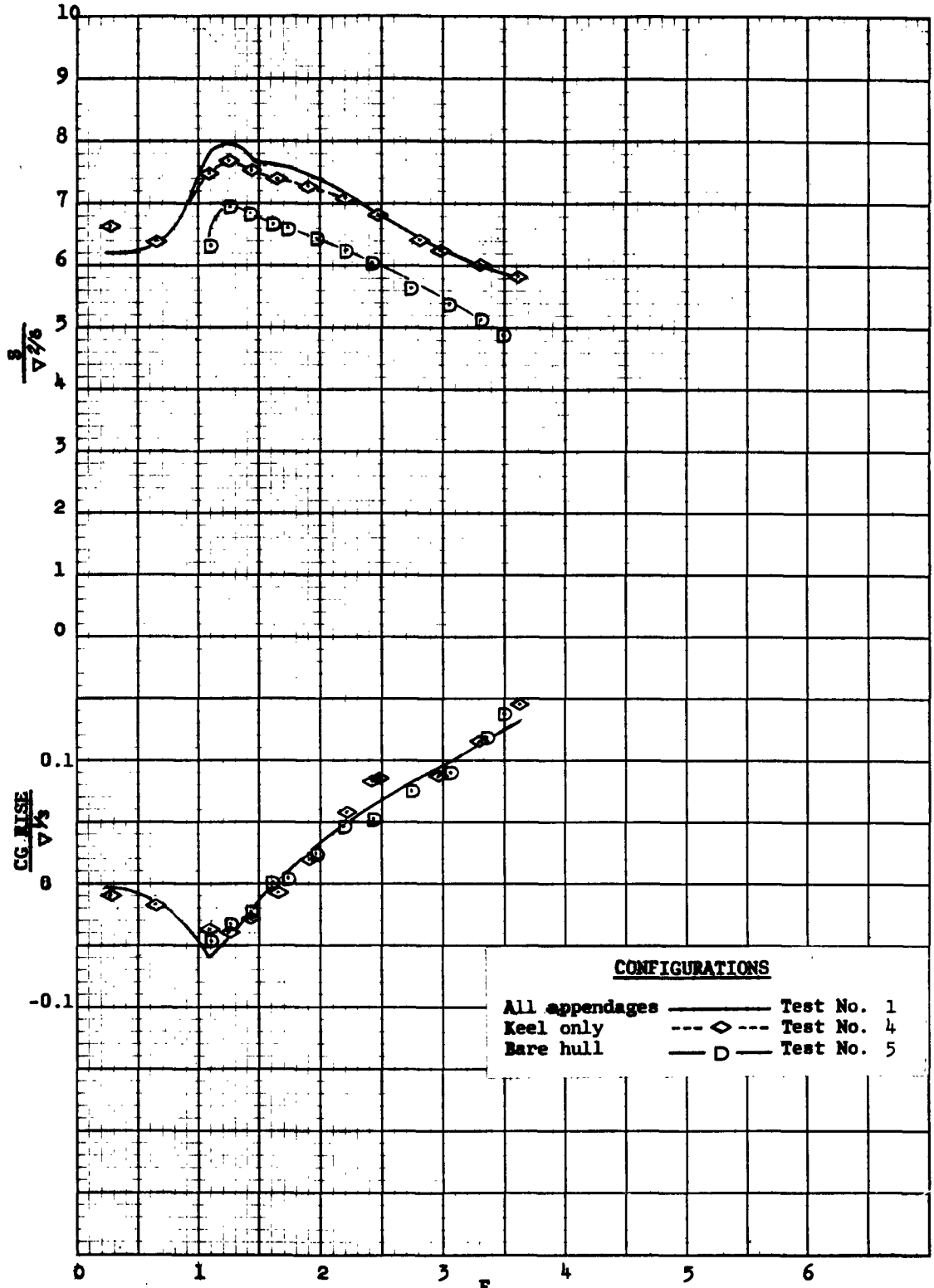


Figure 4b - Variation of Wetted Surface and CG Rise with Froude Number for Three Configurations at a Displacement of 25,000 Pounds and Even Keel

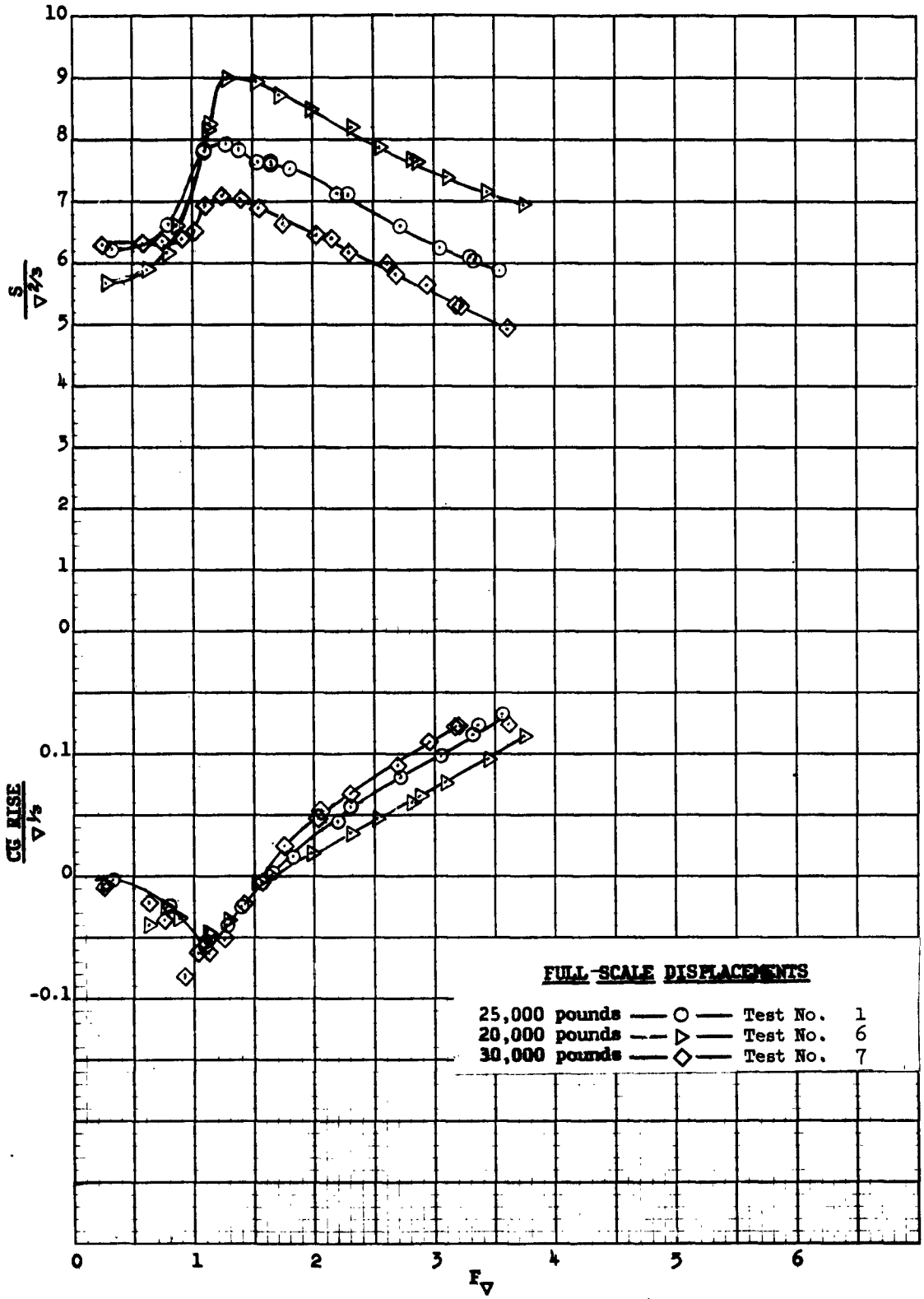


Figure 4c - Variation of Wetted Surface and CG Rise with Froude Number for Three Displacements at Even Keel and with all Appendages

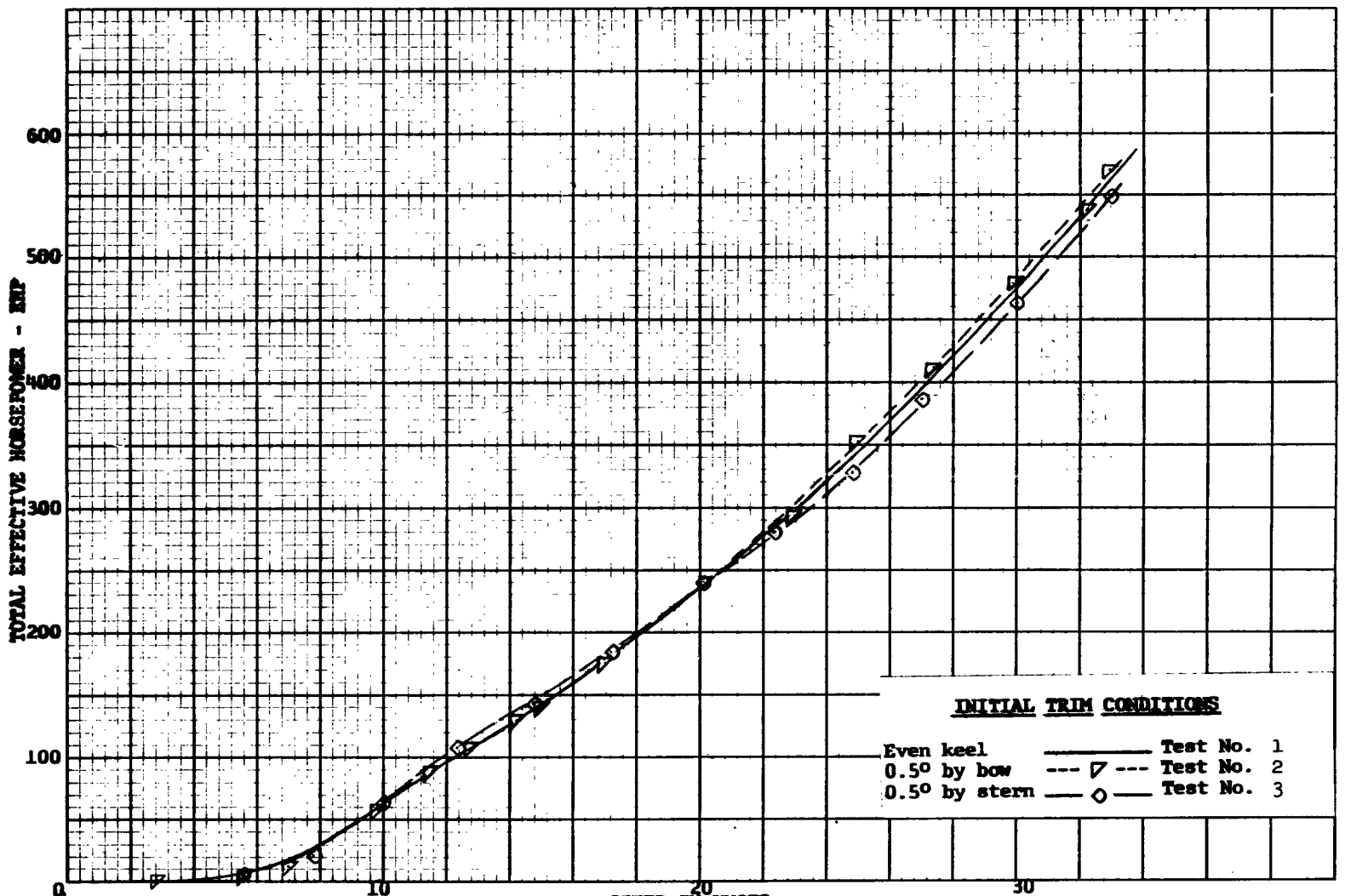


Figure 5a-Full-scale Effective Horsepower for Three Initial Trim Conditions at a Displacement of 25,000 pounds and with all Appendages

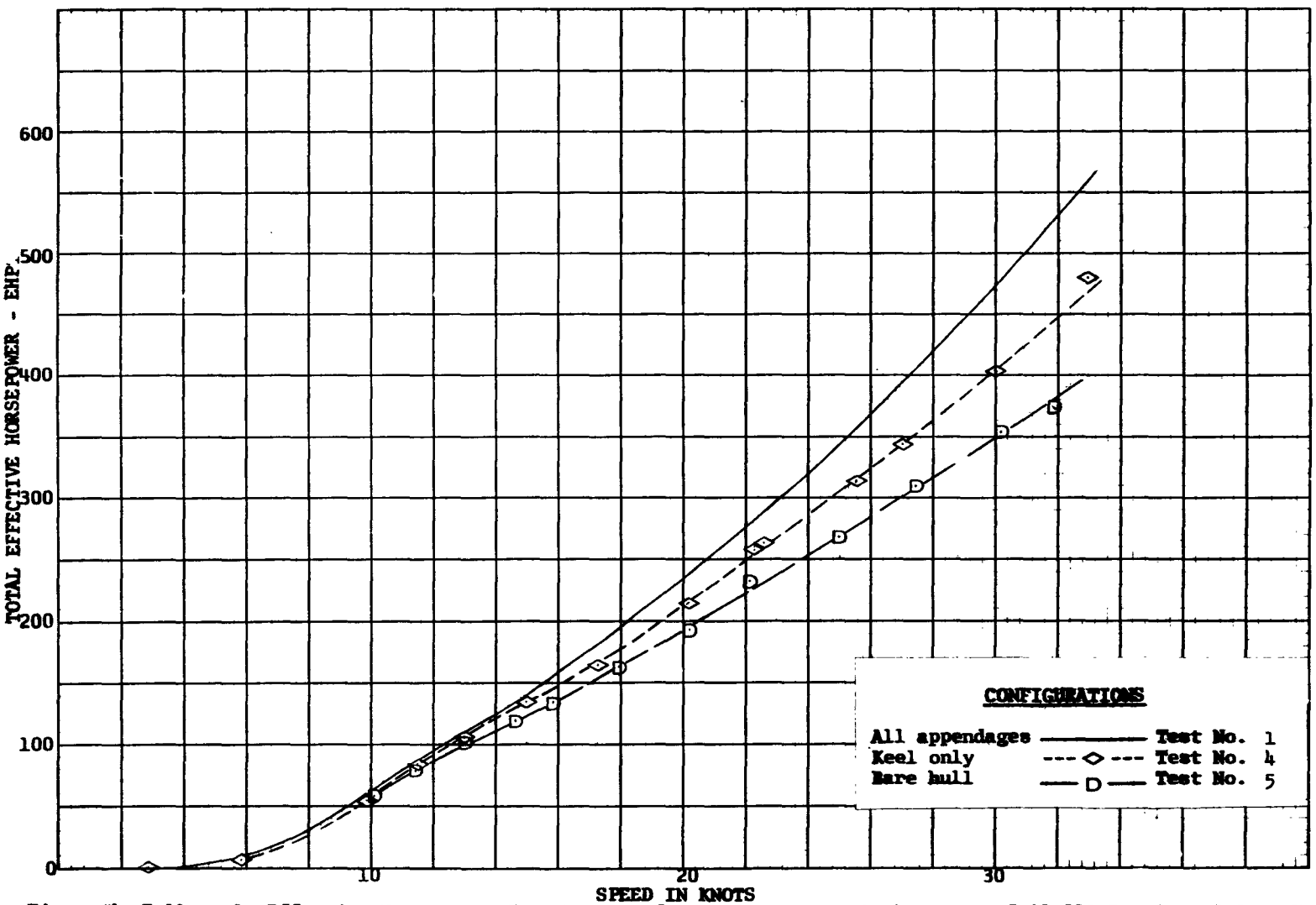


Figure 5b - Full-scale Effective Horsepower for Three Configurations at a Displacement of 25,000 Pounds and Even Keel

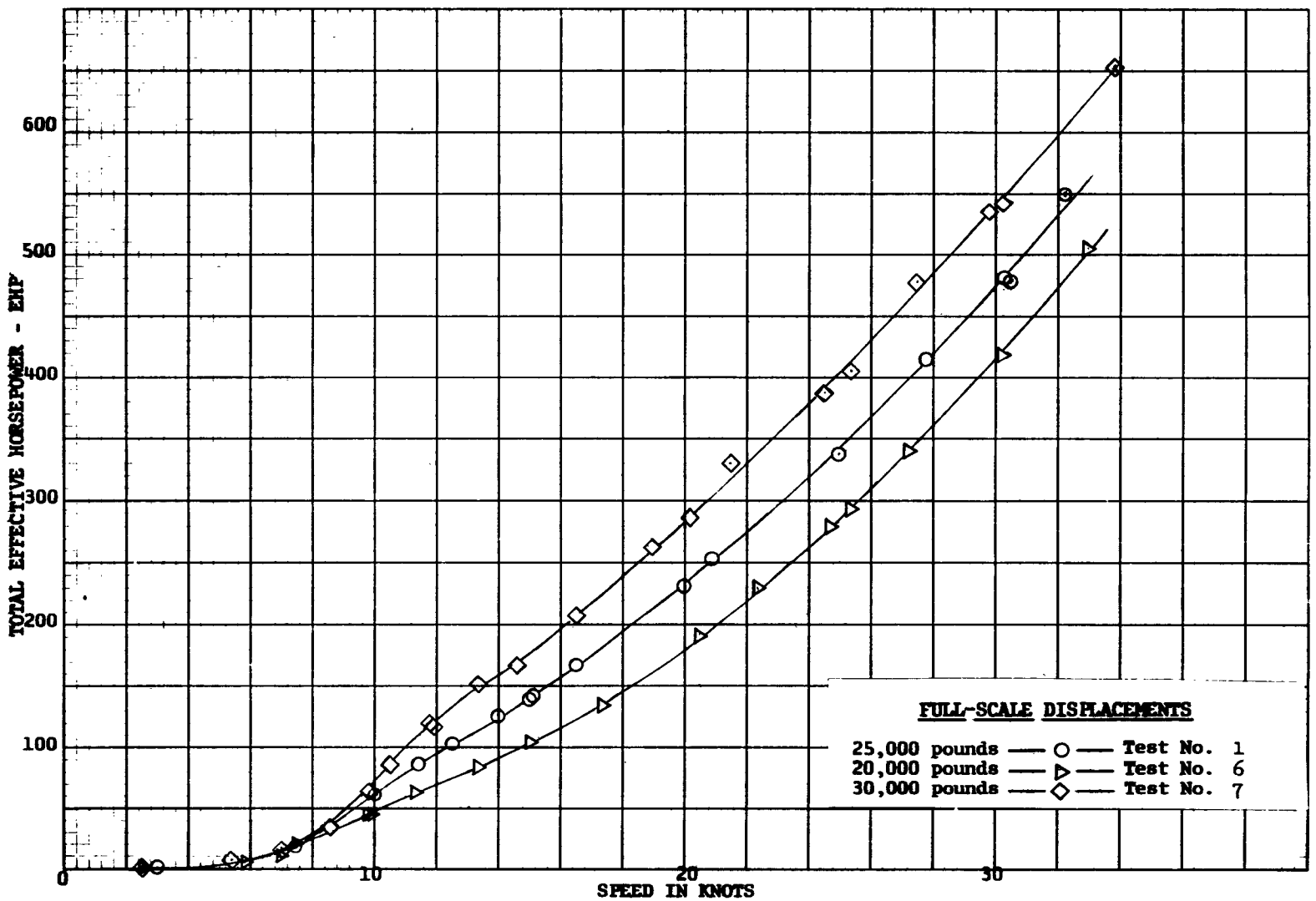


Figure 5c - Full-scale Effective Horsepower for three Displacements at Even Keel and with all Appendages

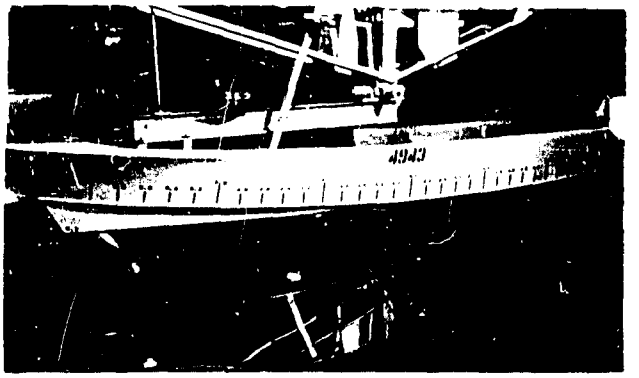


Figure 6a - F_{∇} 0

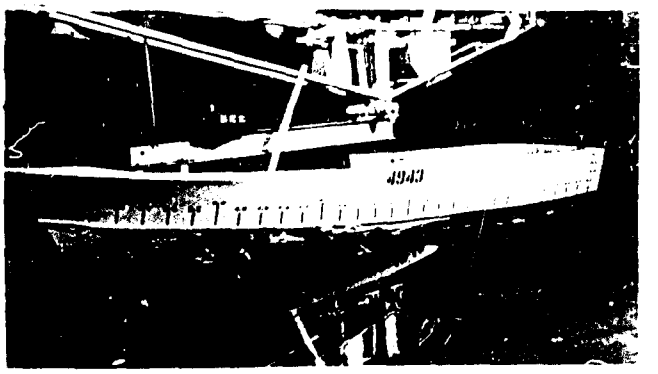


Figure 6b - F_{∇} 1.09

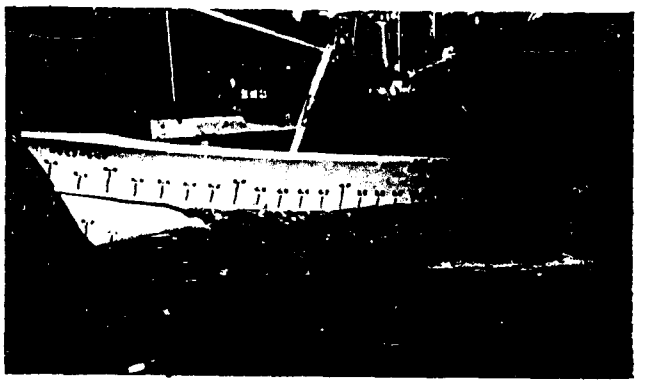


Figure 6c - F_{∇} 1.65

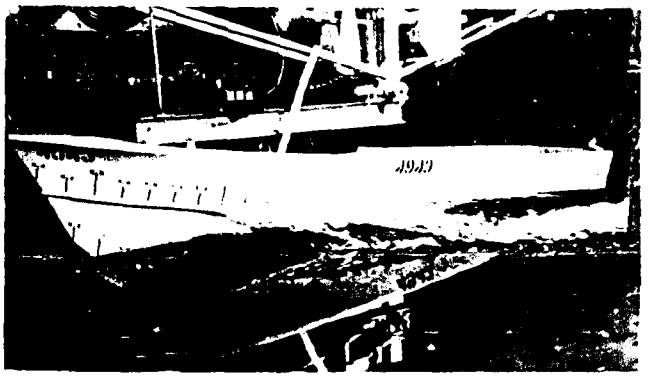


Figure 6d - F_{∇} 2.23

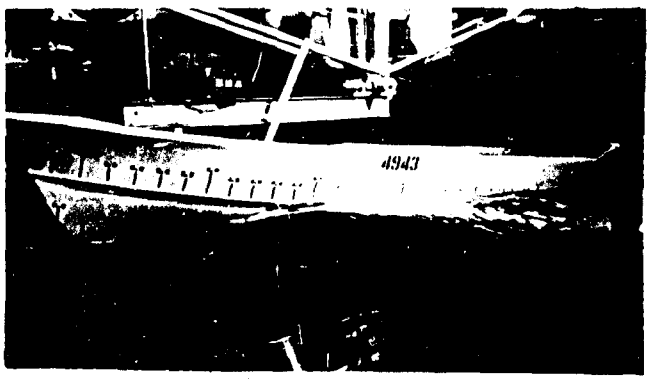


Figure 6e - F_{∇} 2.76

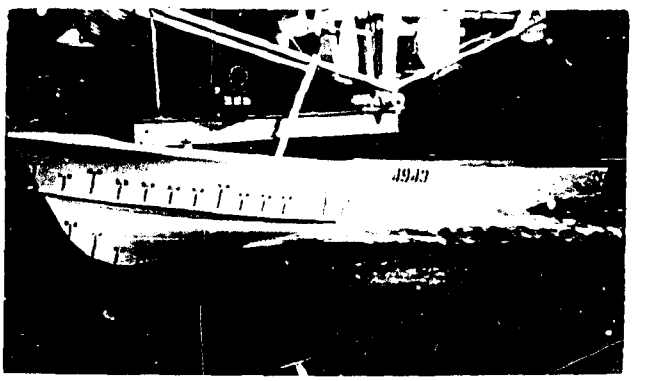


Figure 6f - F_{∇} 3.32

Figure 6 - Spray Characteristics of Model 4943 for a Displacement of 25,000 Pounds with all Appendages and Initial Trim of 1/2 Degree by the Bow

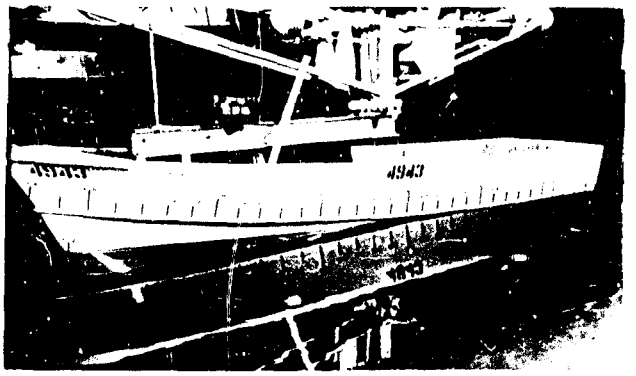


Figure 7a - F_{∇} 0

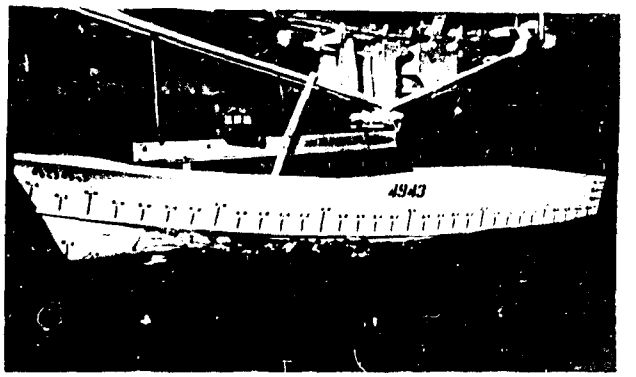


Figure 7b - F_{∇} 1.1

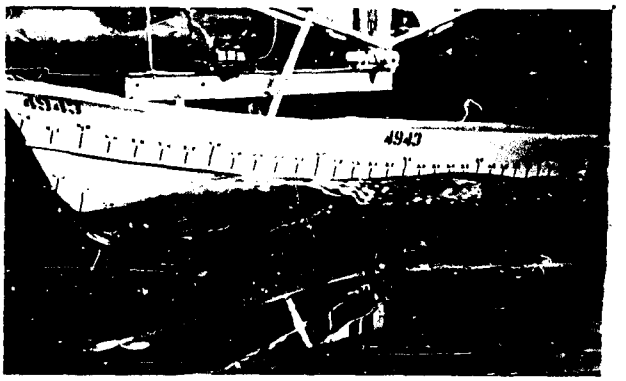


Figure 7c - F_{∇} 1.62

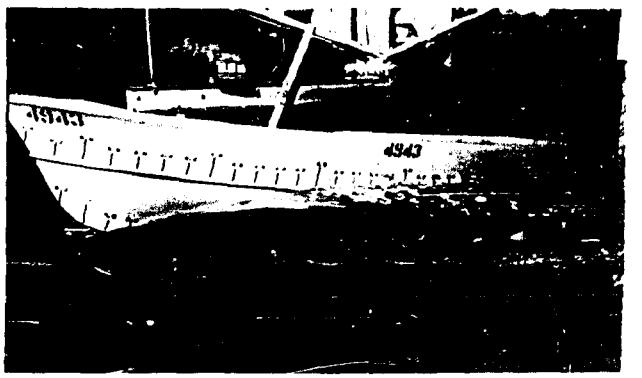


Figure 7d - F_{∇} 2.22

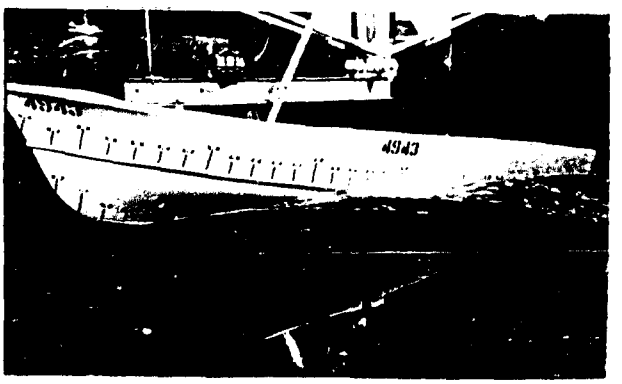


Figure 7e - F_{∇} 2.72

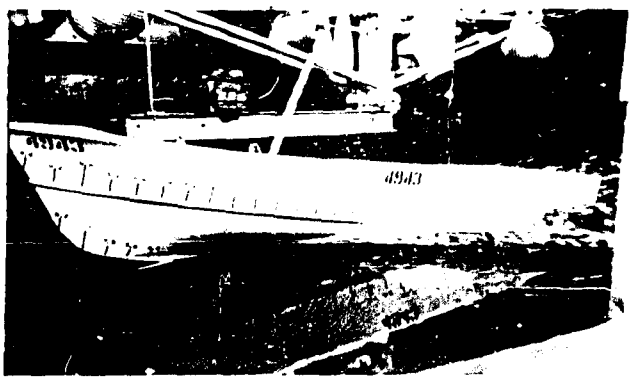


Figure 7f - F_{∇} 3.31

Figure 7 - Spray Characteristics of Model 4943 for a Displacement of 25,000 Pounds with all Appendages and Initial Trim of 1/2 Degree by the Stern

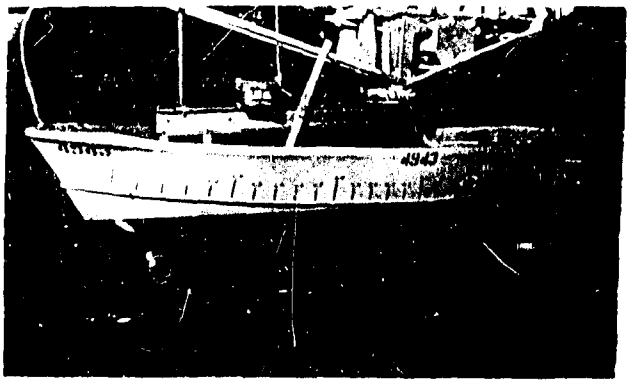


Figure 8a - F_{∇} 0

Figure 8b - F_{∇} 1.11

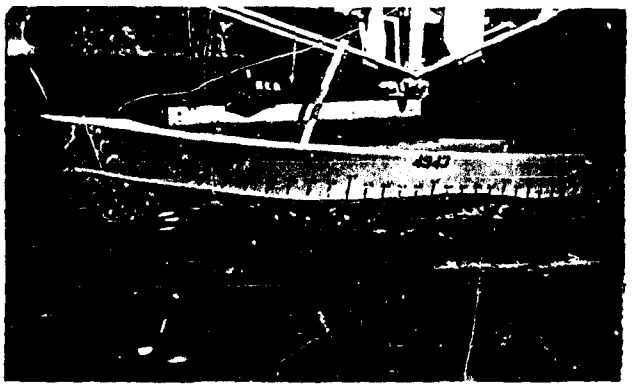


Figure 8c - F_{∇} 1.62

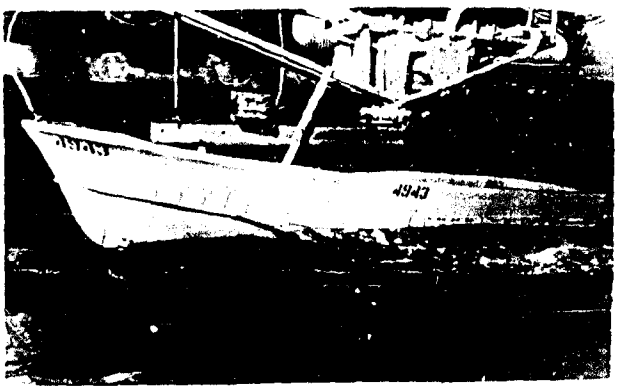


Figure 8d - F_{∇} 2.22

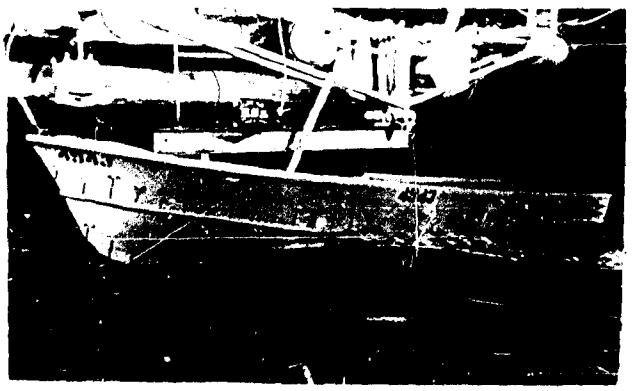


Figure 8e - F_{∇} 2.76

Figure 8f - F_{∇} 3.32

Figure 8 - Spray Characteristics of Model 4943 for a Displacement of 25,000 Pounds with no Appendages and Initial Trim at Even Keel

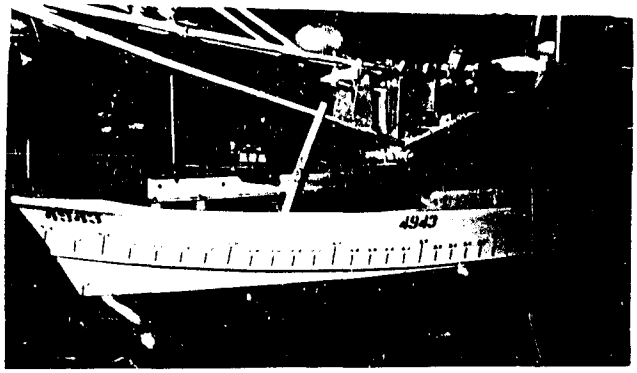


Figure 9a - F_{∇} 0

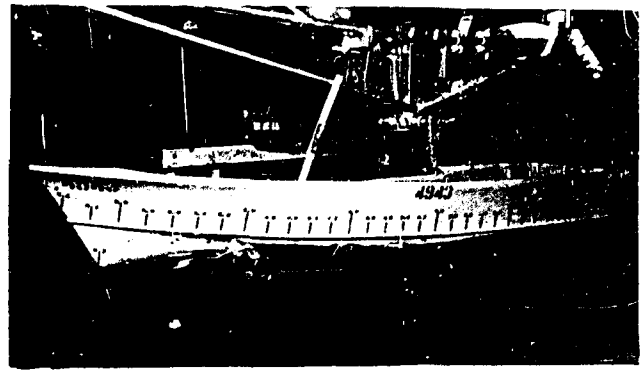


Figure 9b - F_{∇} 1.14

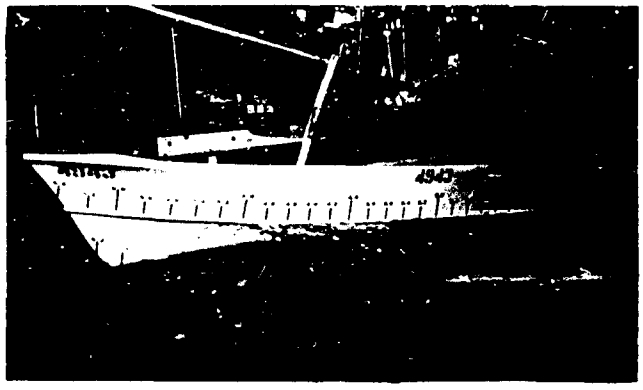


Figure 9c - F_{∇} 1.72

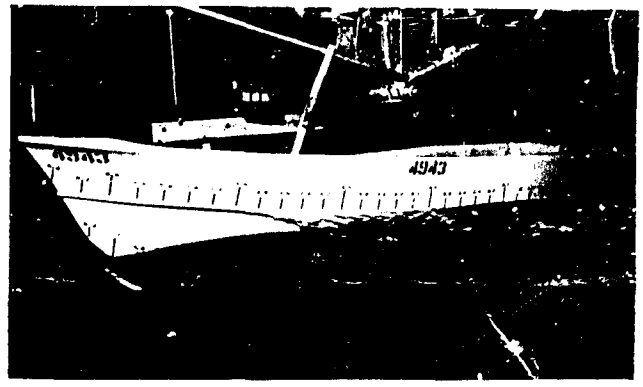


Figure 9d - F_{∇} 2.33

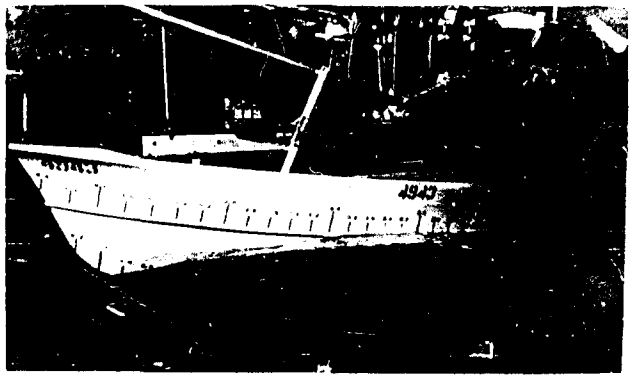


Figure 9e - F_{∇} 2.83

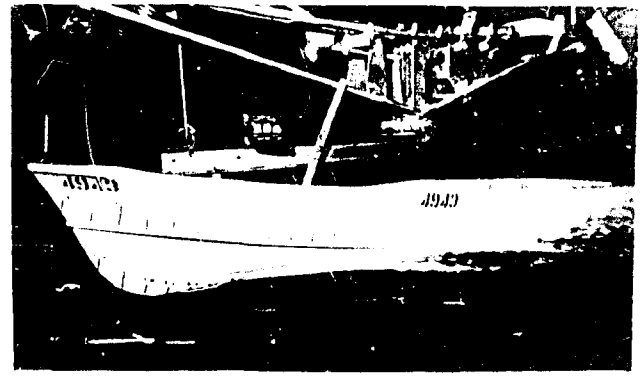


Figure 9f - F_{∇} 3.45

Figure 9 - Spray Characteristics of Model 4943 for a Displacement of 20,000 Pounds with all Appendages and Initial Trim at Even Keel

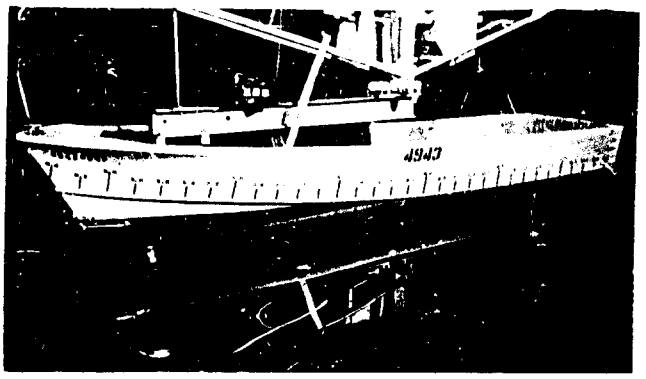


Figure 10a - F_{∇} 0

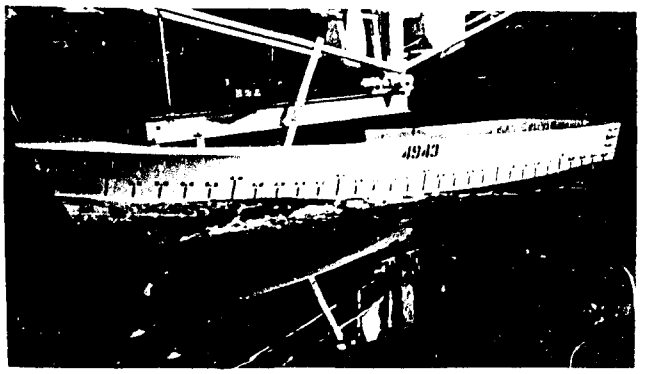


Figure 10b - F_{∇} 1.04

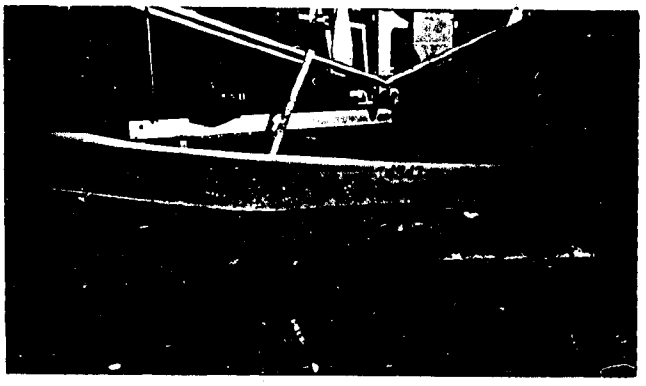


Figure 10c - F_{∇} 1.56

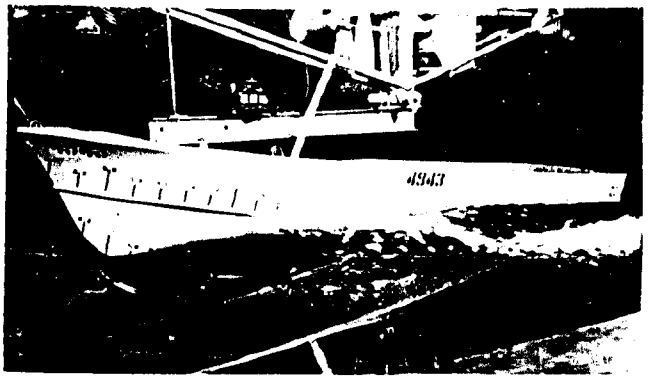


Figure 10d - F_{∇} 2.16

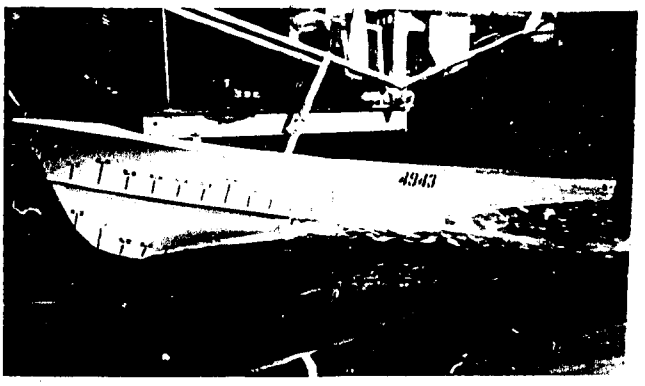


Figure 10e - F_{∇} 2.7

Figure 10 - Spray Characteristics of Model 4943 for a Displacement of 30,000 Pounds with all Appendages and Initial Trim at Even Keel

Figure 11a - F_{∇} 0

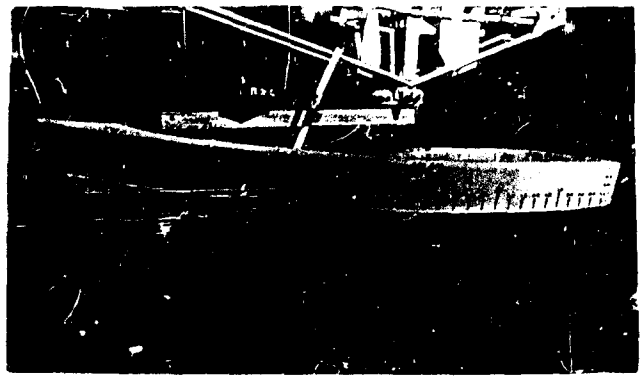


Figure 11b - F_{∇} 1.16

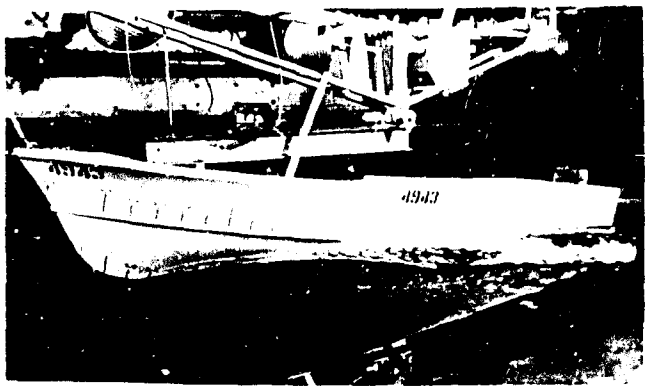


Figure 11c - F_{∇} 2.42

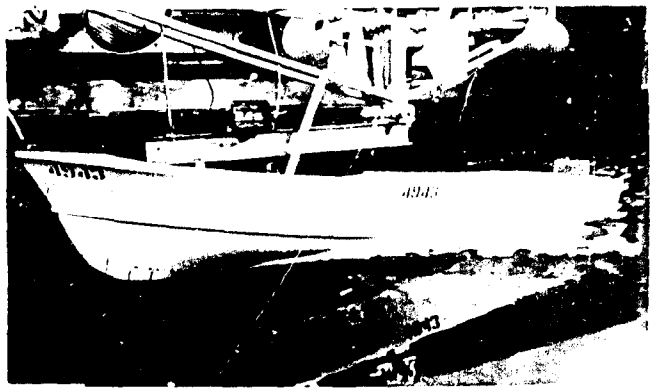


Figure 11d - F_{∇} 3.07

Figure 11e - F_{∇} 4.09

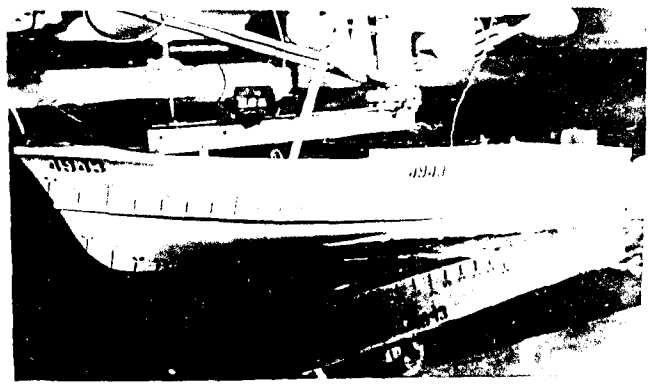


Figure 11f - F_{∇} 5.24

Figure 11 - Spray Characteristics of Model 4943 for the DTMB Standard Condition for Planing Boats

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Tests, using TMB Model 4943, were conducted in Langley Tank No. 1 to determine the performance characteristics of a round bilge 41-foot Personnel Boat. Model resistance, trim, wetted length, and CG rise were measured throughout the speed range for a number of hull loadings, initial trim conditions, and appendage configurations. Comparisons are made with the design condition. Results are presented in dimensionless form.

1. Resistance
2. Boats--Resistance--Model tests
3. Effective horsepower
4. Boats--Model tests
5. Ship models--Model TMB 4943

I. Harbaugh, Kenneth H.
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